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## (54) Coin discriminator.

(57) A coin (5) under test is subjected to the changing magnetic field produced by pulsing of a test coil (1), and the decay of the resulting eddy currents in the coin is monitored by monitoring the coil voltage induced by the eddy currents. The times $T_1$ and $T_2$ at which the coil voltage falls through voltage levels $V_1$ and $V_2$ is measured by comparators (COMP 1, COMP 2) and a microcomputer (7), and those times are compared by microcomputer (7) with stored reference values to help determine the coin type.

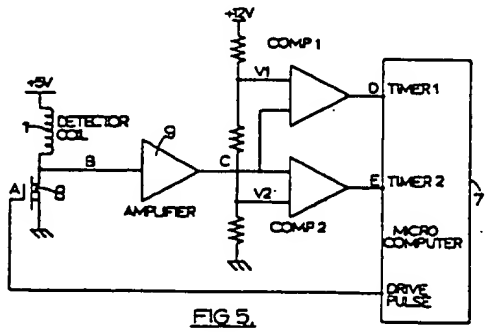


FIG 5.

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Description

# COIN DISCRIMINATOR

This invention relates to coin discriminators. The term "coin" is intended to cover coin-like items such as bogus coins, tokens and circular blanks.

Discriminators employing one or more coils for inductively linking with the coin under test have been used. It has been proposed in Patent Specification G.B. No. 2 041 532A to subject a coil to a voltage pulse and then to monitor the decay of eddy currents produced in a coin by the pulse, in order to test the electrical characteristics of the coin. The decay signal is sampled at predetermined times and is compared with stored reference values appropriate to those times in order to determine the coin type.

We have now realised that it is advantageous to set two voltage levels for the eddy current detection means and to measure the times at which the voltage levels are passed, and to use those times to characterise the coin. One advantage is that there is no need to use an analogue to digital converter, thereby leading to a cost saving.

According to one aspect of the invention a coin discriminator comprises a coin path along which a coin under test is arranged to pass, a coil means positioned adjacent to the coin path, electrical means for subjecting the coil means to a voltage pulse, eddy current detection means adapted to detect the decaying eddy currents induced in the coin by pulsing of the coil means, and monitoring means arranged to detect when the output of the eddy current detection means reaches a first predetermined level and then a second predetermined level, and comparison means for comparing at least one time measurement made by the monitoring means with reference times to determine whether or not there is a concordance between the measured time and a corresponding reference time.

Preferably the times at which the output of the eddy current detection means reaches the first and second levels are each compared with respective reference times, and a concordance between both measured times and corresponding reference times is taken as an indication of a coin type.

A problem with the method of G.B. 2 041 532 is that the proximity of the coin to the test coil/coils affects the magnitude of the eddy currents, and for various reasons some coins may proceed past the test coil/coils at a greater distance from the coil/coils than other coins, for example due to bouncing of the coins. This can lead the discriminator to assign an incorrect value to the coin.

According to a second aspect of the invention a coin discriminator comprises a coin path along which a coin under test is arranged to pass, a coil means positioned adjacent to the coin path, electrical means for subjecting the coil means to a voltage pulse, eddy current detection means adapted to detect the decaying eddy currents induced in the coin by pulsing of the coil means, and monitoring means arranged to measure the time taken for the output of the eddy current detection means to fall from a first predetermined level to a second predetermined level, and comparison means for comparing said time with a reference time to determine whether or not there is a concordance between the measured time and the reference time.

As is known, the eddy current detection means may comprise a sampling coil which is additional to the coil means, or the coil means may itself constitute a sampling coil.

The coil or coils are preferably arranged to be substantially critically damped.

Two coin discriminators in accordance with the invention will now be described, by way of example only, with reference to the accompanying schematic drawings in which:-

Figure 1 is a cross-section through the coin passage of a first discriminator in accordance with the invention showing the single coil;

Figure 2 is a graph showing the coil voltage against time;

Figure 3 is an enlarged version of a graph similar to Figure 2 showing curves produced by a coin at two different distances from the coil;

Figure 4 is a plot of the timing pulse produced by a window detector from one of the curves in Figure 3;

Figure 5 is a block circuit diagram of a second discriminator in accordance with the invention; and

Figure 6 shows plots of signals at various locations in the circuit of Figure 5.

In Figure 1 a single coil 1 is shown mounted in a recess in a non-magnetic support surface or wall 2 defining one side 3 of a coin passage of the discriminator. The coil is, for example, of diameter 2mm and is wound on a ferrite core, the axis of the coil being arranged substantially normal to the surface 3.

Only a single coil 1 is used in this embodiment, the coil 1 being connected both to a pulse circuit and to a monitoring circuit, not shown.

In Figure 2 the coil voltage of the coil 1 is shown, the decay curves (a) and (b) corresponding to voltages induced in the coil by the magnetic field which is produced by the decaying eddy currents, a coin of a conductive material being present for curve (a) but with no coin for curve (b). The flat top 4 to the curve is due to the saturation of the amplifier of the monitoring circuit.

As shown in Figure 1 a coin may proceed along the coin passage in contact with surface 3 as coin 5, or it may be spaced from surface 3, as coin 6. Figure 3 shows two superimposed plots (c) and (d) of the coil voltage due to identical coins which are respectively positioned against surface 3 and away from surface 3. It will be seen that the shapes of the decay portions of the curves (c) and (d) are closely similar, but that the curve (c) represents greater induced voltages than curve (d).

We have appreciated that if an adjustment can be made for that difference in overall voltage level the position of the coin in relation to surface 3 will not

matter to the same degree.

In accordance with the second aspect of the invention this adjustment is achieved by setting two voltage thresholds levels $V_1$ and $v_2$ and measuring the time $T_2$-$T_1$ for the coil voltage to fall from $V_1$ to $V_2$. The time $T_2$-$T_1$ is not significantly different for the two curves (c) and (d), but the corresponding time would be different for a coin of a different type. Figure 4 shows how with a window detector a rectangular pulse of length $T_2$-$T_1$ can be generated for the curve (c). The duration of the pulse $T_2$-$T_1$ is then compared with a series of stored reference values of the time difference to determine the conductivity characteristics of the coin.

In situations in which the coins can be kept in close proximity to the surface 3 the curves of induced coil voltage will have sufficiently consistent parameters to enable the coin types to be characterised by the times $T_1$ and $T_2$ measured separately, the measured times $T_1$,$T_2$ being compared with stored reference sets of $T_1$ and $T_2$ to determine the coin type.

Figure 5 is a block circuit diagram of a second discriminator in accordance with the invention in which times $T_1$ and $T_2$ are separately measured.

A microcomputer applies a drive pulse, signal A (Figure 6), to an electronic switch 8 to pulse coil 1. The detector coil voltage, signal B, is amplified by amplifier 9 and the amplified signal C is compared with two reference voltage levels $V_1$ and $V_2$ by comparators COMP 1 and COMP 2 respectively, the voltage levels $V_1$ and $V_2$ being set on a potential divider.

The microcomputer 7 incorporates a timing function and is programmed to time the occurrence of the pulse edges produced in the outputs, signals D and E, from the comparators COMP 1 and COMP 2, to provide measurements of the times $T_1$ and $T_2$. The microcomputer then compares the measured times $T_1$ and $T_2$ with stored reference sets to determine the coin type. For each coin type the reference set will comprise maximum and minimum values of $T_1$, and maximum and minimum values of $T_2$.

Such discriminators are preferably used in conjunction with other discriminators which measure, for example, coin diameter and coin thickness, to provide an accurate determination of the coin type.

## Claims

1. A coin discriminator comprising a coin path (3) along which a coin (5) under test is arranged to pass, a coil means (1) positioned adjacent to the coin path, electrical means (8) for subjecting the coil means to a voltage pulse, and eddy current detection means (9) adapted to detect the decaying eddy currents induced in the coin by pulsing of the coil means, characterised by monitoring means (COMP 1, COMP 2, 7) arranged to detect when the output of the eddy current detection means reaches a first predetermined level ($V_1$) and then a second predetermined level ($V_2$), and comparison means (7) for comparing at least one time measurement ($T_1$,$T_2$) made by the monitoring means with reference times to determine whether or not there is a concordance between the measured time and a corresponding reference time.

2. A coin discriminator as claimed in claim 1 in which the times at which the output of the eddy current detection means reaches the first and second levels ($V_1$,$V_2$) are each compared with respective reference times, and a concordance between both measured times ($T_1$,$T_2$) and corresponding reference times is taken as an indication of a coin type.

3. A coin discriminator comprising a coin path (3) along which a coin (5) under test is arranged to pass, a coil means (1) positioned adjacent to the coin path, electrical means (8) for subjecting the coil means to a voltage pulse, and eddy current detection means (9) adapted to detect the decaying eddy currents induced in the coin by pulsing of the coil means, characterised by monitoring means (COMP 1, COMP 2, 7) arranged to measure the time taken ($T_2$-$T_1$) for the output of the eddy current detection means to fall from a first predetermined level ($V_1$) to a second predetermined level ($V_2$), and comparison means for comparing said time ($T_2$-$T_1$) with a reference time to determine whether or not there is a concordance between the measured time and the reference time.

4. A coin discriminator as claimed in any of the preceding claims in which the coil means is arranged to be substantially critically damped.

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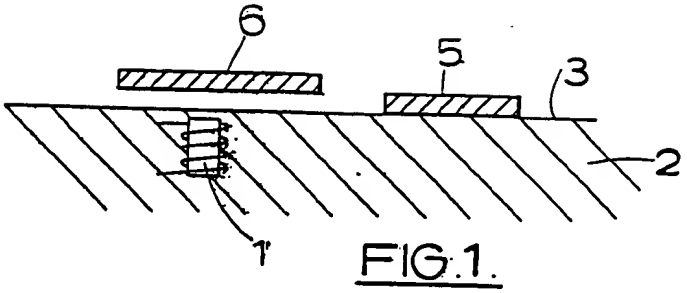


FIG.1.

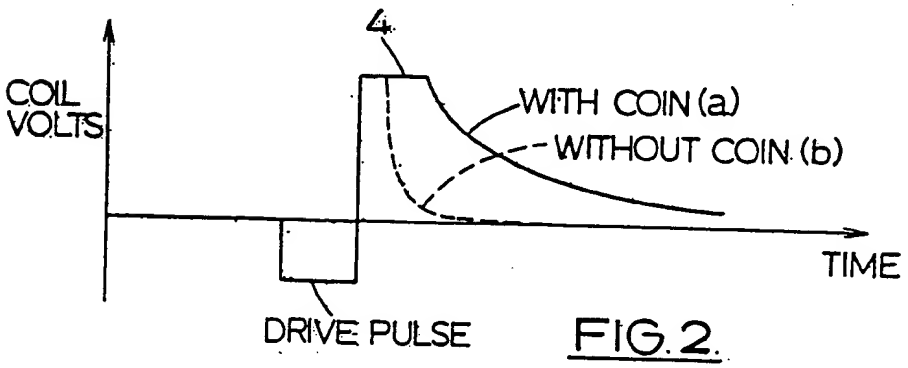


FIG.2.

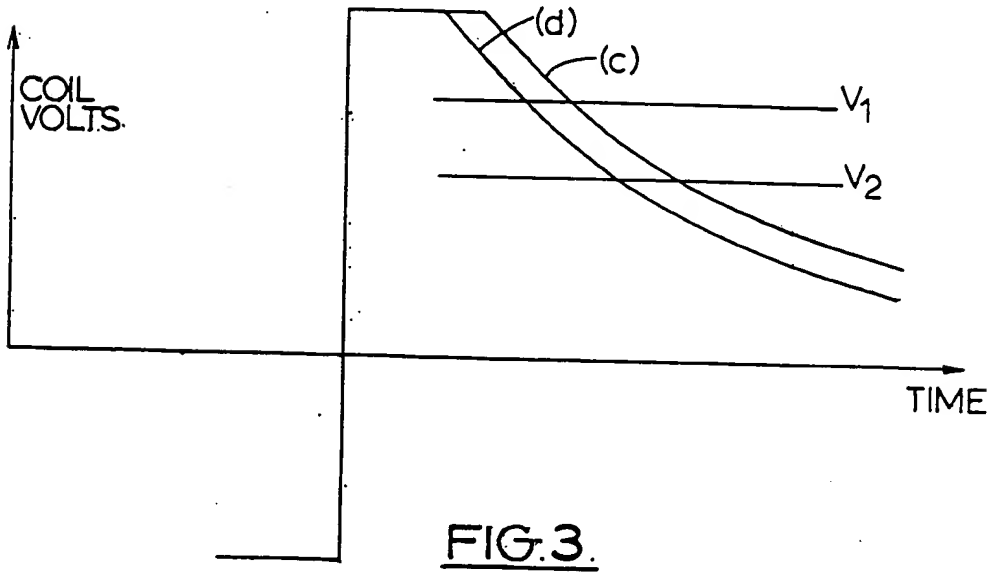


FIG.3.


FIG.4.

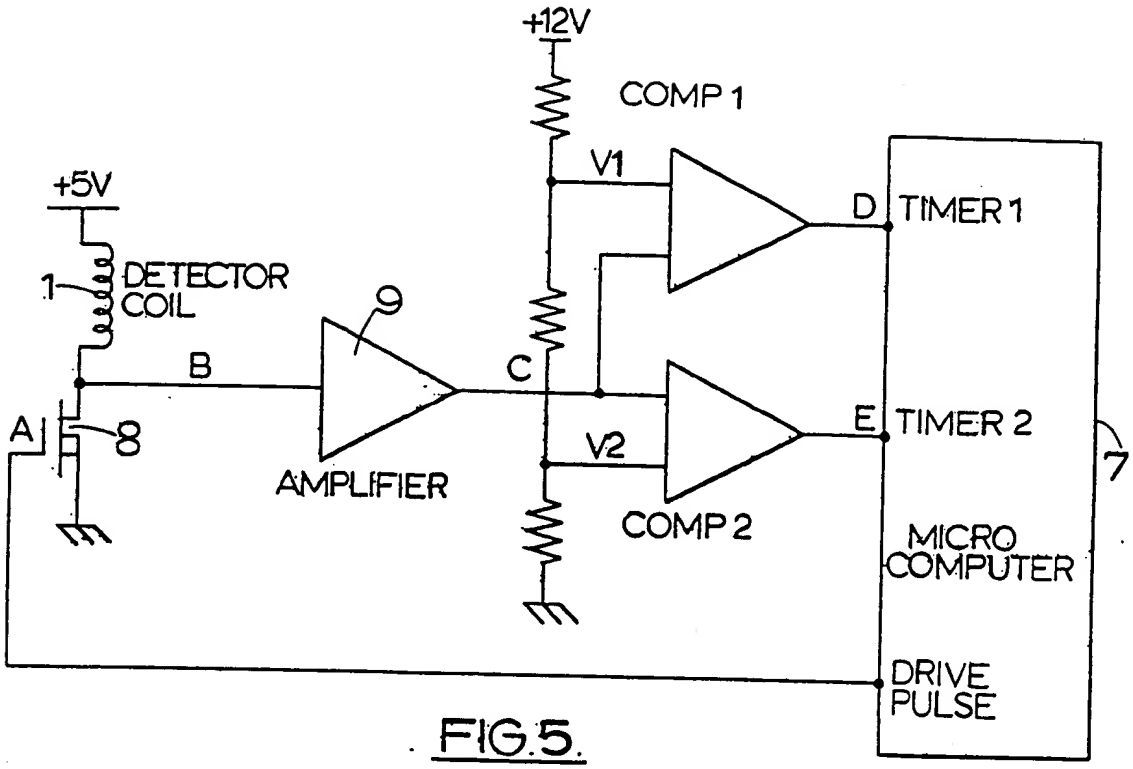
+12V
COMP 1
V1
+5V
D
TIMER 1
1
DETECTOR
COIL
9
B
C
A
8
E
TIMER 2
V2
7
AMPLIFIER
COMP 2
MICRO
COMPUTER
DRIVE
PULSE

FIG.5.

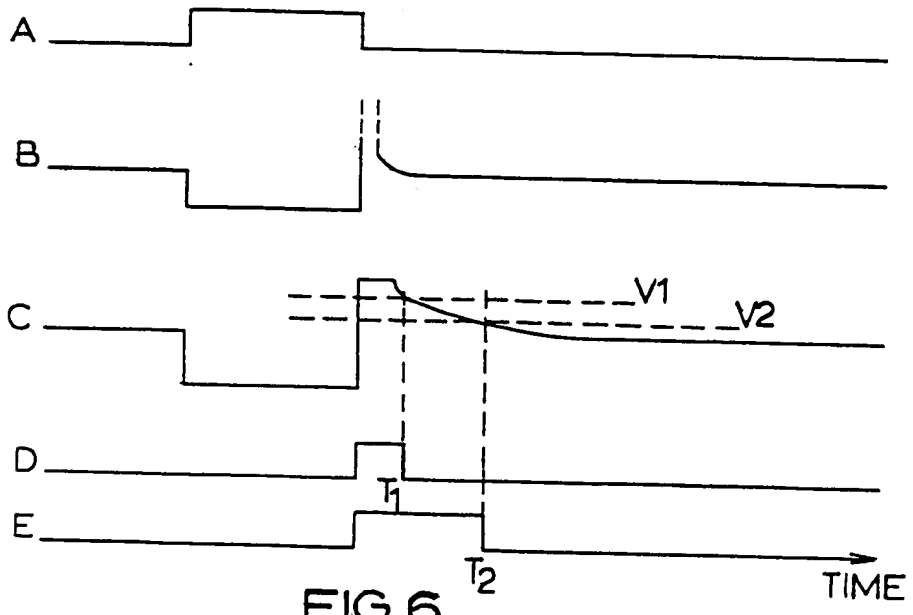
A
B
C
V1
V2
D
T1
E
T2
TIME

FIG.6.